The Whole is Greater than the Sum: An Empirical Analysis of the Effect of Team Based Learning on Student Achievement[1]

Georgeanne M. Artz[2] and Keri L. Jacobs[3]
Iowa State University
Ames, IA

Christian R. Boessen[4]
University of Missouri
Columbia, MO

Abstract

We examine whether teams exert a positive influence on student test scores in three Team Based Learning (TBL) courses at two different universities. We find positive and significant effects on individual exam scores for students at all levels of the ability distribution; on average, an individual's exam score increases roughly six points for every 10-point increase in their teammates' average score. In addition, we find that these positive effects vary little across the ability distribution of teams and individuals, suggesting that the TBL method benefits a continuum of student abilities.

Keywords: Team Based Learning, peer effects, teaching methods

Introduction

"The strength of the team is each individual member…the strength of each member is the team." Phil Jackson.

Team Based Learning (TBL) is a student-centered teaching strategy that harnesses the power of peer learning by having students work in teams throughout the semester. TBL shifts instruction from a traditional lecture-based teaching paradigm to a structured learning sequence. The method includes three phases: 1) individual student preparation outside of class, 2) individual and team based multiple-choice tests based on the assigned reading or other class preparation and 3) active, in-class problem solving exercises completed in student learning teams. (A more detailed explanation of the TBL method can be found in Michaelsen et al. (2004) and Sibley and Ostafichuk (2014)). The amount of in-class time allotted to problem-solving allows the instructor to observe students' thinking, get instant feedback on how well students grasp the material and correct misunderstandings as they occur. In a TBL course, students are required to take on more personal responsibility for assimilating topical information and knowledge since there are fewer lectures. They spend more time applying or "doing" the subject matter in class. As described by Michaelsen et al. (2004), students are regularly required to solve complex problems and make decisions as a group, communicate clearly with one another and collaborate effectively with their peers. We believe these communication and team-work skills have lasting value post-college even if the specific knowledge or information from the course may lose relevance over time.

Case study research on the effectiveness of Team Based Learning reports positive impacts of the method on student outcomes, (Springer et al., 1999, Nokes-Malach et al., 2015). Several studies, particularly in the health professions, report better or equivalent learning outcomes and greater participation as compared with more traditional teaching formats (Hazel et al., 2013; Clark et al., 2008; Searle et al., 2003). In addition, many find improved student attitudes toward learning and working in teams (Espey, 2010). In our own experiences, students consistently report on course evaluations that working in teams makes the course more enjoyable and more effective. For example, one student commented: *"I enjoyed the collaborative work in teams. It is practical and helps prepare us for a real-world job. While it adds some stress to the class work, it is a fresh approach*

[1]Acknowledgements: The authors express thanks to anonymous referees and Dr. Rick Parker for helpful suggestions. The authors are also grateful for the advice and suggestions of Dr. Otavio Bartalotti and Dr. Peter Orazem. Finally, the authors extend a special thanks to the Team Based Learning group at Iowa State University for inspiring the idea for this research. This study was deemed exempt under federal regulation 45 CFR §46.101(b).

[2]Assistant Professor, Department of Economics, 478B Heady Hall, Ames, IA 50011, (515) 294-6260

[3]Assistant Professor, Department of Economics, 469 Heady Hall, Ames, IA 50011, (515) 294-6780

[4]Associate Teaching Professor, Agricultural and Applied Economics, 201 Mumford Hall, Columbia, MO, 65211, (573) 882-7620

to teaching. You can only learn so much from a slide deck and this class pushed students to work together and collaborate in order to be successful." Other students express frustration with their team experience in the course evaluations. The most common frustrations related to team members who don't do enough, or who do too much: *"Some of the students in our group didn't pull their weight."*

In general, we observe that more students report positive than negative experiences and outcomes from the TBL format on course evaluations. While the anecdotal evidence suggests that TBL can at least improve student attitudes without detracting from learning and, at best, improve student learning and make class more fun, there is to date little quantitative analysis on TBL effects on student performance. In this paper, we focus on measuring the effects of teams on student test scores in Team Based Learning classrooms. A few studies of medical and pharmacological students have reported significantly higher final exams scores in TBL courses relative to non-TBL formats (Persky, 2012; Koles et al., 2010; Thomas and Bowen, 2011; Kubitz, 2014). To our knowledge, this is the first study of the effect of teammate's performance on undergraduate student test scores in a TBL setting. Specifically, we want to assess whether and for whom teams have positive effects on individual performance and conversely, if and for whom, teams may produce negative (or worse than expected) outcomes. We evaluate the following claims regarding the effect of Team Based Learning on student outcomes: 1) teams exert a positive influence on individual performance, 2) the effects of teams vary by the ability of the team and 3) the effects of teams vary by the ability of the individual. We find a positive impact of teammates' performance on individual performance. In addition, we find that these positive effects vary little across the ability distribution of teams and individuals, suggesting that the TBL method is a robust teaching approach that benefits a continuum of student abilities.

Linking Peer Effects and Student Achievement

The empirical evidence of peer effects on academic performance at the college level is relatively limited (Sacerdote, 2011; Epple and Romano, 2011). Identifying peer effects is difficult because of issues of self-selection (students sort into particular schools or classes, for example) and "reflection," the idea that peer effects work in two directions: not only are a student's outcomes influenced by his peers, but he influences his peers' outcomes as well, particularly when they are together for some time (Manski, 1993). At the college level, it is also challenging to identify the relevant group of peers that may affect an individual's behavior.

"Roommate studies," which measure peer effects of randomly assigned college roommates on student academic performance are mixed in their findings, some finding small positive effects and others finding no evidence of peer effects (Sacerdote, 2001; Zimmerman, 2003). More recent research that better defines peer groups and includes better controls for individual ability before group formation is also mixed. In a study of freshman at the U.S. Air Force Academy, Carrell et al. (2009) find positive and significant peer effects by squadron, especially in math and science courses. In addition, they find weak evidence that the effects are larger (and positive) for students in the bottom third of the ability distribution. The implication, they suggest, is that placing low-ability students into peer groups with high ability peers can improve student performance.

Peer effects studies at primary and secondary school levels find wide ranging effects. However, Sacerdote (2011) notes two consistent themes in this literature. First, gender variation matters. Classrooms with higher percentages of females have higher test scores (Hoxby, 2000; Lavy and Schlosser, 2011). Second, peer effects are non-linear, although the evidence on the nature of the non-linearity is mixed. Some studies find that students at the lower end of the ability distribution benefit more from the presence of high ability peers than do students at the high end of this distribution, while others find that higher ability students experience the largest peer effects. For example, Burke and Sass (2013) report that students with low initial achievement levels appear to benefit less from an increase in the average ability of their peers than do students with higher initial scores. Lower ability students may even experience negative effects as the average ability of their peer group increases. Lavy et al. (2012) find that having a large fraction of low ability peers significantly and negatively affects the achievement of schoolmates, while average ability and the proportion of high ability peers does not seem to matter.

One implication of the above studies' findings is that team construction and composition matters. An important facet of the TBL method and a distinction from traditional group learning, is how teams are constructed. According to Michaelsen et al. (2004), three principles are paramount to team formation: 1) teams are selected by the instructor, 2) the instructor should devise a strategy to create diversity in the teams and 3) the selection process should be transparent to the students. Teams are formed by the instructor to "distribute class resources," deliberately mixing students of varied ability together in teams to roughly balance the expected performance of each team in the class. To implement this, the instructor considers the characteristics or skills believed to determine success in the course (e.g., writing skills, math skills, attitude and experience with course-related material) and constructs teams to diversify groups along these criterion. Students remain in their teams for the entire semester.

Data and Methods

To evaluate the effect of teams on individual performance, we use individual student data collected in three different economics courses – Intermediate Microeconomics, Cooperatives and Agribusiness Finance – across two universities. All are taught from econom-

ics or agricultural economics departments and primarily service undergraduates pursuing economics or agricultural business degrees.

These courses utilize the essential elements of TBL and, importantly, followed the prescribed TBL team construction methods. Following Michaelsen et al. (2004), teams in this study were deliberately formed to mix students of varied ability and backgrounds together in teams to roughly balance the expected performance of each team in the class. For example, in the intermediate microeconomics course, students were allocated to teams based on their reported grade point average (GPA), major and gender. The objective was to roughly equalize the average grade point average across teams, while ensuring a mix of majors and gender on each team. Teams were formed in a similar fashion in the other two courses. In all courses, instructors used administrative data from course enrollment files for student rank (i.e., freshman, sophomore, junior, senior), gender and major. Students' GPAs were self-reported on a beginning-of-the-semester student information sheet in which they were asked, "What is your cumulative GPA at <institution>?"

The TBL method of team formation differs in notable ways from other studies that examine team and peer effects. First, our peer groups are small relative to studies of peer effects at the classroom or cohort level, consisting of between four and eight students per team. Second, the length of interaction as a team is shorter in our data, one semester as opposed to a year or more in the studies cited above. In a large peer group of classmates, students may not have frequent, direct interaction with their higher- or lower-ability peers. A central tenant of TBL is that team members work and interact closely with team peers in almost every class period, which is the case with the teams in our study. We know the peer groups in our courses interact because we require them to do so in class. Finally, teams are formed by the instructor, but not randomly assigned.

Our empirical strategy is to use a student random effects framework to detect the effects of teammates' test performance on individual test scores, controlling for individual ability (GPA), other personal characteristics (e.g., major, gender) and course-specific variables. Our measures of student achievement are test scores in the courses. In each course, multiple end-of-unit exams are given during the semester. The repeated observations on each student allows us to employ panel estimation techniques and control for unobserved individual attributes. We estimate the following student random effects regression using data from the three courses:

$$S_{ijk}=\alpha_i+\delta_1 P_{j-i,k}+\delta_h P_k^h x\ P_{j-i,k}+\delta_l P_k^l x\ P_{j-i,k}+\beta\ '\ X_i+\varepsilon_{ijk} \quad (1)$$

where *i* denotes students, *j* denotes teams and *k* denotes the exam. $P_{j-i,k}$ is the average score on test *k* of team *j* excluding individual *i*. Its coefficient, δ_1 measures the impact of teammates' exam performance on the student's individual score, controlling for individual attributes and ability; this is our primary measure of the team effect. The student characteristics vector, X_i, includes student's overall GPA, gender and a dummy variable equal to 1 if the student is an Economics or Agricultural Business major and 0 otherwise. Students with majors in economics or agricultural business may have a different motivation for taking the course and thus different incentives to perform than outside majors. However, it is unclear whether majors will perform better or worse. Students may perceive the class to be closely related to their field and work to perform better, or they may be uninterested in the course but required to take it to meet their graduation requirements.

To investigate whether the team effects vary across the distribution of team performance, we create two dummy variables. The first, P_k^l, takes a value of 1 if team *k*'s average score on the exam was in the bottom quartile of the class distribution and zero otherwise. Similarly, P_k^h, takes a value of 1 if team *k*'s average score on the exam was in the top quartile of the class distribution and zero otherwise. These dummy variables are interacted with $P_{j-i,k}$ to investigate if peer effects in the bottom and top quartiles of the class distribution differ significantly from the average effect. We constructed comparable dummy variables, P_i^l and P_i^h by the distribution of individuals' GPA and interacted them with $P_{j-i,k}$ to examine the third claim that peer effects vary by the ability of individuals.

According to Sacerdote (2011) there are two main approaches to measuring and identifying peer effects. First is exogenous variation in the assignment of peer groups. While the TBL instruction strategy relies on a non-random assignment of students to teams, students are assigned to teams exogenously, by the instructor rather than through self-selection. Second, student fixed effects are often included to control for self-selection into classrooms. We also exploit this strategy by using panel data estimation techniques to account for the repeated observations on individual students and including dummy variables for courses. While we cannot separate the peer effects that result from peers' background (what Manski (1993) terms exogeneous effects) from those that result from peers' current outcomes (Manski (1993) calls these endogenous effects), we can analyze the existence, direction and magnitude of any existing peer effects. Regardless of the precise channel through which peer effects operate, having a better understanding of the relationship between an individual's performance and the performance of a small group of peers with whom they work closely over the course of a semester does provide useful information about whether and how, the TBL teaching method affects student outcomes.

Results and Discussion

Table 1 provides descriptive statistics by course. The number of students in the courses ranged from 42 in Agribusiness Finance to 75 in Cooperatives. Two exams were given in the Cooperatives and Agribusiness Finance courses, while a total of six tests were given in Intermediate Microeconomics. Note that the individual average scores for all three courses are roughly equal.

The microeconomics course has a somewhat larger variance in demonstrated performance by students and their teams. The student-reported overall GPAs indicate a student average of approximately 3.0 on a 4.0 scale in all three courses. The proportion of majors (economics and agricultural business) to non-majors is approximately equal in Intermediate Microeconomics and Cooperatives, but 88% of the students in the Agribusiness Finance class are majors. The proportion of women in the courses ranges from a high of 45% in Cooperatives course to a low of 28% in Intermediate Microeconomics.

Table 2 presents descriptive statistics on the teams. Our main criteria for sorting students into teams is GPA. The fact that teams are constructed to be balanced is evident in the lack of variation in average GPA across teams and a simple regression of GPA on team dummy variables by course showed no significant differences in average GPA across teams. We also strive to include a mix of gender and majors on each team, however; these are somewhat less evenly balanced across teams. Nevertheless, the key idea is that teams begin on an "even playing field" at the beginning of the semester in terms of observable attributes.

Table 3 presents the main results of the random effects regressions. We estimate four versions of equation (1). Model (1) includes only the team effect, while Model (2) adds individual attributes. Model (3) adds the interaction terms to assess whether team effects vary at the upper and lower end of the team distribution; Model (4) includes the comparable measures for the individual distributions. We conduct the estimation for all three courses combined including course fixed effects to control for any observed differences across courses and instructors that may affect exam performance.

The first claim implied by the TBL strategy is that teams exert a positive influence on individual performance. This is corroborated in our data. The average team effect, $P_{j-i,k}$, is significant and positive in Model 1. In Model 2, controlling for individual characteristics, the average team effect is 0.62. The interpretation is that a student's own test score increases 0.62 points for every 1-point increase in his or her teammate's average score. This is not a trivial effect. For example, a one standard deviation increase in teammate's average score would raise an individual's score roughly four or five points – at least a letter grade, using a standard grading scale

Table 1. Descriptive Statistics by Course

	Intermediate Microeconomics		Cooperatives		Agribusiness Finance	
	Mean (std. dev.)	Min/Max	Mean (std. dev.)	Min/Max	Mean (std. dev.)	Min/Max
$IndivScore_i$	72.93 (13.15)	25.5 / 104	73.11 (11.37)	44.4 / 108	73.98 (12.30)	42 / 98
$TeamAve_{j-i}$	72.81 (8.17)	54.75 / 89.25	73.11 (5.91)	60.15 / 83.29	73.98 (4.71)	66.29 / 81.21
GPA	3.06 (0.58)	1.60 / 3.90	2.97 (0.58)	1.53 / 4.00	3.17 (0.43)	2.13 / 3.91
AgBus/Econmajor	0.58 (0.49)	0 / 1	0.49 (0.50)	0 / 1	0.88 (0.32)	0 / 1
Male	0.72 (0.45)	0 / 1	0.55 (0.50)	0 / 1	0.62 (0.49)	0 / 1
Number of students	43		75		42	
Number of exams	6		2		2	
Max number of observations	258		150		84	

Table 2. Descriptive Statistics by Team

	Intermediate Microeconomics				Cooperatives				Agribusiness Finance			
Team	Mean (std. dev.) GPA	Min/ Max	% Male	% Major	Mean (std. dev.) GPA	Min/ Max	% Male	% Major	Mean (std. dev.) GPA	Min/ Max	% Male	% Major
1	3.072 (0.55)	2.33 3.83	100	80	2.821 (0.71)	1.53 4.00	57	43	3.05 (0.50)	2.13 3.60	71	100
2	3.000 (0.62)	2.21 3.90	75	0	3.02 (0.57)	2.23 4.00	63	63	3.03 (0.49)	2.24 3.61	63	75
3	2.936 (0.57)	2.18 3.75	80	40	2.848 (0.41)	2.17 3.30	57	57	3.158 (0.44)	2.61 3.77	57	86
4	2.948 (0.58)	2.30 3.80	60	40	2.98 (0.61)	1.70 3.67	43	57	3.25 (0.41)	2.73 3.88	57	86
5	3.017 (1.03)	1.60 3.80	75	25	3.073 (0.56)	2.10 3.60	63	25	3.29 (0.43)	2.74 3.91	57	86
6	3.223 (0.39)	2.80 3.71	75	100	2.78 (0.61)	1.95 3.47	71	71	3.21 (0.27)	2.94 3.54	67	100
7	3.210 (0.50)	2.84 3.90	75	50	3.01 (0.56)	2.20 3.61	38	36				
8	3.09 (0.60)	2.30 3.67	50	100	3.01 (0.60)	2.00 3.90	25	36				
9	3.263 (0.28)	2.90 3.54	50	75	3.124 (0.45)	2.50 3.65	57	43				
10	3.00 (0.48)	2.31 3.44	75	75	3.056 (0.66)	1.63 3.84	75	13				
Course Mean	3.06 (0.58)	1.60 3.90	72	58	2.97 (0.58)	1.53 4.00	55	49	3.17 (0.43)	2.13 3.91	88	62

Table 3. Results: Effect of Teammates' Performance on Student Achievement (S_{ijk}), All Courses Combined[a]

	Actual Teams			
	(1)	(2)	(3)	(4)
	0.584***	0.620***	0.383***	0.599***
	(10.74)	(12.84)	(4.36)	(11.99)
			-0.065***	
			(4.55)	
			0.039***	
			(2.69)	
				0.009
				(0.27)
				0.067**
				(2.00)
GPA_i		13.58***	12.97***	11.42***
		(10.56)	(11.01)	(3.84)
$AgBus/Econmajor_i$		-1.11	-0.86	-0.31
		(0.78)	(0.62)	(0.24)
$Male_i$		0.71	0.89	1.16
		(0.59)	(0.75)	(0.95)
constant	30.379***	-13.25***	5.86	-7.39
	(7.28)	(2.77)	(0.92)	(0.75)
N	489	423	423	423
R-sq	0.0649	0.4048	0.4491	0.4241
F-test of joint significance				
Low quartile			0.001	0.000
High quartile			0.000	0.000

[a]Includes course dummy variables with Intermediate Microeconomics serving as the base. These dummy variables are insignificant in all 4 models.

Notes: Asterisks denote significance: *p<.05; **p<.01; ***p<.001

with +'s and –'s. This estimate should be considered an upper bound of the teammate's effect given the potential reflection and non-random assignment issues in our empirical design.

The sign and significance of the team effect is robust to the addition of individual characteristics, indicating the student random effects effectively controls for unobserved student-specific attributes. Not surprisingly, grade point average (GPA) is strongly positively correlated with individual test scores, but gender and major do not seem to matter.

The second claim we evaluate is that team effects vary by the 'ability' of the team. Despite instructor efforts to distribute individual student resources roughly equally among teams, team performance does inevitably vary and sometimes a great deal. In fact, the range in team averages on the exams in our data is as high as 27 points. To the extent that any measured peer effects also vary with overall team performance, instructors may look for better ways to construct the teams in their courses to mitigate some of this variation. On the other hand, if there is no apparent difference in the size of the team effect between high- and low-performing teams, it would suggest that the current methods are acceptable and that they are not giving an unfair advantage or disadvantage to certain teams.

Model (3) examines whether the team effect varies for high- and low-performing teams. The results in Table 3 for Model 3 suggest there is little difference in the magnitude of the team effect for teams at the top quartile or the bottom quartile of the distribution relative to teams in the middle of the distribution. The coefficient for low quartile teams (P_k^l=1), is negative and significant, but it is quantitatively very small, reducing the team effect by six-hundredths of a point from 0.38 to 0.32. The coefficient for top quartile teams, (P_k^h=1) is positive and significant, but again, very small, increasing the team effect from 0.38 to 0.42. The bottom row of the table reports the p-values for an F-test of joint significance for the interaction terms and $P_{j\neq i,k}$, verifying that the effect is positive and significant across the distribution of team performance. Figure 1 shows the average estimated effects along with the 95% confidence interval. These vary little across the three groups. Perhaps the comfort from this finding is that there appears to be only minor ramifications of team qualifications and performance vis-à-vis the "messiness" of resource distribution in team formation. A possible implication is that there are potential across-the-board gains to activities directed at "team building" and efforts or incentives to stimulate team activities and performance. Importantly, the peer effect remains positive and strongly significant at all levels of the team distribution.

The final claim we analyze in this paper is that peer effects vary by the ability of the individual. Some instructors believe that TBL helps higher ability students more than lower ability students. With TBL, students do teach each other. To the extent that the best way to learn something is to teach it, much of the benefit of TBL may accrue to the higher ability students who often assume the teaching role. Others believe that TBL may have greater effects on lower ability students in that it encourages them to be more engaged and ask more questions, particularly of their peers. Results here indicate that both these instructor intuitions may have merit. The results for Model (4) suggest that peer effects do not vary much by individual student ability as measured by GPA. The effect is significantly larger for students in the top quartile of the ability distribution, raising the estimated effect of teammate's performance from 0.60 to 0.67. However, there is no significant difference between students at the low end of the ability distribution and those in the middle.

Figure 2 plots the average effect and 95% confidence interval across ability groups. Similar to Figure 1, the overlapping confidence intervals suggest little difference across the groups, although the estimated effect of teammates' performance is larger for higher ability students. A potential concern is that GPA is a questionable indicator of "ability" for team formation purposes. Alternatively, a lack of difference in the team effects

Figure 1. Estimated Effect of Teammate's Performance on Individual Performance, by Team Performance

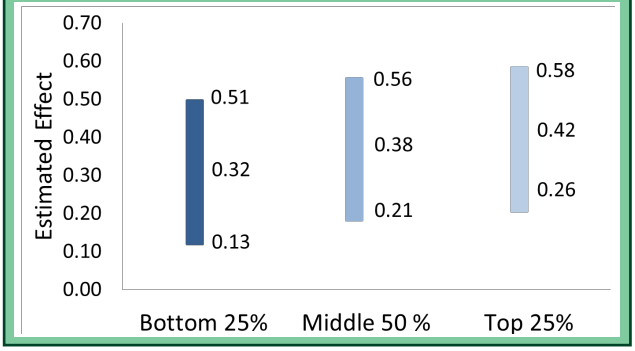
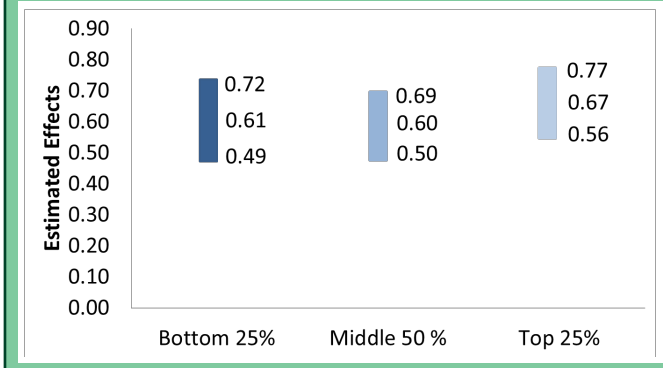


Figure 2. Estimated Effect of Teammate's Performance on Individual Performance, by Individual Performance



Note: Graphs show the point estimate and 95% confidence interval for the peer effect by quartile.

for high and low GPA students could indicate the TBL approach benefits different students via different mechanisms or pathways as per the commonly perceived benefits of TBL. If GPA is a reasonable indicator of ability, then the implication is that TBL is a very robust teaching approach that benefits a continuum of student abilities.

Summary

For instructors considering significant pedagogical changes in the classroom, a common concern is the uncertain benefit of contemplated changes relative to the time and energy necessary to make the changes. Furthermore, there is always the concept of "unintended consequences" in that a new method may help certain types of students but potentially make other types worse off. This paper addresses these issues and concerns with respect to Team Based Learning.

The TBL technique engages students in a course, allowing them to discover the material largely through group exploration and exercises and by building cohesive team units. TBL continues to gain popularity and there are several reasons to suspect that it has positive effects on students' enjoyment of the class and the development of the "soft skills" that are necessary beyond the classroom. To date, however, there is little empirical evidence to judge whether TBL does influence student performance in the course. For an instructor considering switching to TBL, confidence that team activities help the individual students is perhaps a primary motivation to make the switch. This team effect on individual performance was the focus of our investigation.

We conducted an empirical test of the effectiveness of Team Based Learning on student performance using student characteristics and performance from three undergraduate courses. We find evidence of significant positive effects of a team's exam performance on individual test scores. On average, the effects are meaningfully large: a 10-point increase in teammates' average test score may raise a student's exam score by 3 to 6 points. In addition, we find that while the estimated peer effect is positive and significant on average for students at all ability levels, there is little evidence that these effects are different for students in the top or bottom quartile of the grade point average distribution. This combination of findings implies that TBL is a very robust approach for helping the entire spectrum of student abilities in the classroom. Finally, there is evidence that team ability has only a small effect on individual performance: higher performing teams marginally improve the performance of its members by more than low performing teams. From an instructor's perspective, this finding implies there is some leeway in the process of allocating resources in team formation.

This research improves our understanding of the benefits of Team Based Learning and other collaborative learning and teaching methods, provides insight into how to form more effective teams in our classrooms and will likely generate ideas among those who have used and want to implement TBL into their classroom. It suggests that in addition to previous research findings demonstrating that TBL enhances student enjoyment and engagement in the course, there are positive effects on student learning as measured by exams. Many practical questions remain that this analysis is unable to address, such as: what is the mechanism that generates the variation in peer effects, are there other student characteristics that matter for determining TBL effectiveness, is there a "best" way to assign and structure teams and what does that depend on and how can instructors further enhance the peer effects for lower ability students? Future exploration into these questions may help those instructors using or planning to implement TBL in their classrooms design more effective and engaging learning environments for their students.

Literature Cited

Burke, M. and T. Sass. 2013. Classroom peer effects and student achievement. Journal of Labor Economics 31(1): 51-82.

Carrell, S., R. Fullerton and J. West. 2009. Does your cohort matter? Measuring peer effects in college achievement. Journal of Labor Economics 27(3): 439-64.

Clark, M.C., H.T. Nguyen, C. Bray and R. Levine. 2008. Team-based learning in an undergraduate nursing course. Journal of Nursing Education 47(3): 111-117.

Epple, D. and R. Romano. 2011. Peer effects in education: A survey of the theory and evidence. In Benhabib, J.A. Bisin and M.O. Jackson (eds.). Handbook of Social Economics 1(11): 1053-1163.

Espey, M. 2010. Valuing teams: What influences student attitudes? NACTA Journal 54(1): 31-40

Hazel, S., N. Heberle, M. McEwen and K. Adams. 2013. Team-based learning increases active engagement and enhances development of teamwork and communication skills in a first-year course for veterinary and animal science undergraduates. Journal of Veterinary Medical Education 40(4): 333-341.

Hoxby, C. 2000. Peer effects in the classroom: Learning from gender and race variation. NBER Working Paper 7867.

Koles, P.G., A. Stolfi, N.J Borges, S. Nelson and D.X. Parmelee. 2010. The impact of team-based learning on medical students' academic performance. Academic Medicine 85(11): 1739-1745.

Kubitz, K.A. 2014. The evidence, please. In J. Sibley and P. Ostafichuk (ed.) Getting started with team-based learning. Sterling, VA: Stylus Publishing, LLC.

Lavy, V. and A. Schlosser. 2011. Mechanisms and impacts of gender peer effects at school. American Economic Journal: Applied Economics. 1-33.

Lavy, V., O. Silva and F. Weinhart. 2012. The good, the bad, and the average: Evidence on ability peer effects in schools. Journal of Labor Economics 30(2): 367-414.

Manski, C. 1993. Identification of endogenous social effects: The reflection problem. Review of Economic Studies 60(3): 531-42.

Michaelsen, L.K., A.B. Knight and L.D. Fink. 2004. Team-based learning: A transformative use of small groups in college teaching. Sterling, VA: Stylus Publishing, LLC.

Nokes-Malach, T.J., J.E. Richey and S. Gadgil. 2015. When is it better to learn together? Insights from research on collaborative learning. Educational Psychology Review 27(4):1-12.

Persky, A.M. 2012. The impact of team-based learning on a foundational pharmacokinetics course. American Journal of Pharmaceutical Education 76(2): 1-10.

Sacerdote, B. 2001. Peer effects with random assignment: Results for Dartmouth roommates. Quarterly Journal of Economics 116(2): 681-704.

Sacerdote, B. 2011. Peer effects in education: How might they work, how big are they and how much do we know thus far? Chapter 4 in Handbook of the Economics of Education 3: 249-277.

Searle, N.S., P. Haidet, P.A. Kelly, V.F. Schneider, C.L. Seidel and B.F. Richards. 2003. Team learning in medical education: Initial experiences at ten institutions. Academic Medicine 78(10): S55-S58.

Sibley, J., P. Ostafichuk and L.K. Michaelsen. 2014. Getting started with team-based learning. Sterling, VA: Stylus Publishing, LLC.

Springer, L., M.E. Stanne and S.S. Donovan. 1999. Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis. Review of Educational Research 69(1): 21-51.

Thomas, P.A. and C.W. Bowen. 2011. A controlled trial of team-based learning in an ambulatory medicine clerkship for medical students. Teaching and Learning in Medicine 23(1): 31-36.

Zimmerman, D.J. 2003. Peer effects in academic outcomes: Evidence from a natural experiment. The Review of Economics and Statistics 85(1): 9–23.